Advanced decoding and classification algorithm development

Background: The primary method of signal acquisition for prosthesis control utilizes electromyography (EMG), the electrical signals generated by the muscles during their contraction. Most commonly a direct control and associates the activity of a single muscle with a movement on the prosthetic limb is used. Recently, machine learning based methods have become commercially available that rely on high density of sensors to acquire more detailed features of muscle movement patterns that occur in the residual limb. Here, patterns generated by multiple muscles are taught to a machine learning algorithm, which in turn attempts to decode intended outcome during real-time use. This method provides greater functionality; however, it is sensitive to the many environmental and internal noise conditions causing it to generate erroneous outcomes than its predecessor.

Goal of the project: The algorithms developed in our lab aim to significantly reduce the effects of noise on the classification outcomes. Furthermore, the fundamental aim is to move closer to natural movements that determine precise position. The input data is not limited to surface EMG; IMU (inertial measurement unit) and ultrasound data are other modalities utilized. Our laboratory, i.e. current/former students, have developed high performance machine learning methods. The first task of the prospective student will be to familiarize themselves with the literature, the problem, ongoing work in signal processing and machine learning. Next, the student can begin algorithm development and experimentation building on the foundations already in existence in the lab. The final step would be develop 'real-time' implementation for online decoding and control of prostheses.

Benefits to the student: The opportunity to get hands on experience in the development of cutting-edge signal processing and machine learning algorithms, conducting experiments with human subjects in the relevant patient population, and the potential for journal publication. This project is funded by NIH, and will be jointly carried out with collaborators at Infinite Biomedical Technologies, giving the student startup/small company collaboration and translational research experience.

Skills/Experience:

- *Skills and background knowledge in machine learning:* This project will require strong knowledge of signal processing and machine learning methods. The student should be motivated to take suitable courses, and later must be able to understand the underlying mechanism and math behind these algorithms and build on them in an innovative fashion.
- *Advanced coding skills in Matlab and Python:* testing the sensor system requires interfacing with software components. Modifying, debugging and using these components requires a fundamental understanding of the programming languages. The student should have prior experience coding in both Matlab and Python with experience beyond class assignments, as these are the languages in which current lab infrastructure exists.
- *Self-motivation and the ability to conduct independent work:* The student should take the current pattern recognition and machine learning algorithms to realistic, 'real-time' prosthesis environments, and test them in augmented reality and then on amputees. New ideas and independent work are highly encouraged and valued in the lab. However, this also entails taking suitable courses, improve skills, and then translate learned material to practice.

Expectations: Motivation to translate the technology for amputee needs. Publication and/or patenting of the original work is a must.